MICROSCOPIC ORGANISMS IN THE BUFFALO WATER-SUPPLY AND IN NIAGARA RIVER.

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It will help us to understand our subject more clearly if we obtain some idea of the character and extent of the source whence our organisms are taken. The Niagara River, from its head at Lake Erie to the Falls of Niagara, is fully twenty miles in length. It contains many islands, one of which, Grand Island, is six or seven miles in width by twelve miles long, dividing the river for that distance into two streams, each in many places nearly a mile wide. From an estimate based upon the best information to be obtained, including local and state documents, I find that the total area of water along the whole twenty miles cannot be less than 20,000 acres. This comprises the main stream or streams, which are deep and clear, but which have never been explored for microscopic purposes, and the numerous shallow bays and lagoons along the margins, which are full of interest to the general naturalist, and a happy hunting-ground to the microscopist.

The source of the Buffalo water-supply is an inlet-pier placed in the river about a mile and one-third from the lake, where the current is very swift, although about twenty-four feet deep. Such being the case we can readily see that the source of microscopic organisms in the water-supply can only be from the lake and the mile or more of the river above the inlet-pier. To obtain objects from the water-supply for microscopic examination I have simply to

attach a muslin bag to my domestic hydrant, allowing a small stream of water to flow through it for half an hour. The bag is then taken off, turned inside out and rinsed in a tumbler of water, which is allowed to stand a while, the sediment being retained for examination. In this way, with some variations, the microscopists of Buffalo were in times past able to supply themselves and friends with all the material that the most sanguine could desire. At this time I made some experiments and calculations to ascertain, if possible, the amount of organic microscopic matter passing down the river at a given time. I found that it would be safe to estimate at least one grain of matter to twelve gallons of water. Prof. D. S. Kellicott of the State Normal School, found on one occasion, by actual measurement, 3.5 grains to one cubic foot, or 6.12 gallons. This is nearly seven times as much as my estimate. I learned from the maps and surveys of the city that the river at the Water-works, including the canal and harbor, is 2,000 feet wide, with an average depth of 17.5 feet, thus presenting a surface in section of 35,000 square feet. The speed of the river at this point is set down on the maps at six miles an hour. Good judges consider it underrated. Six miles an hour is 528 feet in a minute, or 8.8 feet in a second, so that if we give our square feet length and multiply 35,000 by 528, we have 18,480,000 cubic feet of water passing a given point in one minute. Again, if we multiply 18,480,000, the *cubic feet*, by 6.12, the number of imperial gallons in one cubic foot, we have 113,097,000 gallons passing every minute. One grain of organic matter to every twelve gallons would give us 9,424,750 grains, and as there are 7,000 grains in one pound avoirdupois, we obtain in round numbers 1,346 pounds of organic matter passing a given point in one minute, or 40 tons an hour, or 960 tons in twenty-four hours. These startling figures are the result of calculations based upon the idea that the conditions of the river were indicated by the character of the water-supply at the time. Whether this is really so is still an open question. The phenomenon of so much organic matter, mostly diatoms, passing down the river was then considered of the most interesting character, whether viewed from a microscopical or a geological standpoint. Unfortunately however, from some cause not really understood,

there has been since the summer of 1878 a falling off both as to quantity and quality of the material, so that now it is frequently useless for days or even weeks together to attempt to collect anything.

This falling off is conspicuous in diatoms and other *algæ*; also in animal life. Perhaps there is an increase of starch grains and an indescribable and undefinable *debris*, the examination of which may receive attention at some future day.

The enquiries arising naturally from these statements are: Was the abundance of organic life in the water-supply previous to the summer of 1878 a fair indication of the condition of the water in the river? or, second, did the organisms generate in the water-mains? or, in other words, is the falling-off in quantity and character due to a diminution of life in the river, or to the more rapid flow through the mains as a result of an increased population of the city?

These questions are worthy of consideration from a sanitary point of view, as well as from the standpoint of a microscopist, but can only be answered by a series of observations lasting through several years, with carefully recorded results.

It has been known to us for a long time that hydrants in different parts of the city yielded objects of a different-character, especially in animal life. A lady brought to me for examination a number of *naid worms* taken from her kitchen hydrant. Two or three blocks from her residence another hydrant was known to yield several of the *Hydra fusca* in each pint of water. Another party complains through the daily paper that his hydrant water is so vile as not to be fit for his horses to drink. These hydrants are at least a mile and a half from the pumping-house, while my own, yielding me pure drinking-water and no collectable matter to speak of, is within half a mile from the same.

From these statements it seems plain that some microscopical forms are generated in the mains. The remedy I ventured to suggest in a newspaper article recommending the authorities to cause a more uniform flow of water through every main in the city.

But Buffalo is not the only city in which a diminution of microscopic material in the water-supply is noticeable. Complaints come to us from Cleveland and Chicago that it is now impossible to collect material as in former years.

Previous to the falling off, the most conspicuous of all the *Diatomaceæ* found in the Buffalo water-supply was the well-known form *Stephanodiscus Niagaræ*. This large diatom was sometimes found by the thousand in almost every filtering from October to March or April. During the summer months it was occasionally found in great quantities, but with no degree of certainty. Its great prevalence, and the ease with which it was taken, made it familiar to every microscopist, and render it deserving of more than a passing notice. I believe it was once thought to be peculiar to the rivers and lakes of the St. Lawrence; but it is now known to exist in other rivers and lakes of North America. Prof. H. L. Smith says he has found it in gatherings from rivers of New England, and Mr. B. W. Thomas, of Chicago, informs me that he has found it in the rivers and lakes of Wisconsin, Illinois and Michigan. The diatom, so far as I know, is always found free, and generally in single frustules, although it may sometimes be found in twos and threes. The valves are circular, equal, punctate with a fringe of marginal teeth. On many occasions I have found attached to these diatoms, and to a few other kinds, certain small, zöospore-like bodies, which, for a long time, were undefinable. During the month of May of this year, I found some of the same little bodies on *S. Niagaræ* and on *Asterionella formosa*, and determined, if possible, to ascertain what they were. By the use of very high powers, and great care in focusing and adjusting the light, I found them to be small flagellate monads. I could see plainly the "ear-like" points and the flagella, but, from their close proximity to the diatom, it required patience and some manipulative skill to define them. I have many times seen these little monads attached, singly or in groups, to other diatoms, not infrequently causing the diatom to move in a very unnatural manner.

I have found other attachments or growths upon the margin of *S. Niagaræ*. In January 1874, Prof. H. L. Smith called my attention to certain long filaments or slender hairs proceeding from each tooth of the diatom. He had only seen them once or twice, and no one else had, that he was aware of. In a few days I had the pleasure of finding the same things, and obtained a large gathering, so as to be able to make several slides, some of which I

have by me at this time. From examinations made this last winter upon a few affected in the same way, I am convinced that no satisfactory explanation of the growth has yet been made. Those that I mounted in 1874, and those found during the last winter, show the filaments all placed radially, not absolutely so, but with a remarkable degree of regularity, which it seems impossible they could assume unless moved by some vital force within the diatom itself.

One other peculiarity I have noticed in this remarkable diatom, which, if constantly observed, may in time throw some light on the filamentous growths. If you place a few of a clear gathering on your slide, without cover-glass, and allow the water to evaporate as it will in a warm room, you may see under the microscope any one or two you may fix your eye upon dart instantly out of sight when the line of evaporation reaches the diatom. I have never seen this phenomenon in any other diatom.

With the scanty gathering of *S. Niagaræ* found last winter, there were also a few small *Cyclotellæ*, which displayed the well-defined annulus to which I have many times called the attention of some microscopists during the past eight years, and concerning which I published a short article in the *American Monthly Microscopical Journal* for January of this year. This annulus which surrounds some of the discoid diatoms is of great interest to me, and some to whom I have shown it. It seems, however, to have been overlooked by microscopists, probably through failure to obtain diatoms in the living state. I have repeated the observation within the past few months with increased interest, and can make no abatement in anything I have said with reference to it, or in urging all who may have opportunity to examine the living diatoms themselves with special reference to this appearance. While sketching these remarks, I have under the microscope, in the center of the field, a *Stephanodiscus* and a small *Cyclotella*. The first has no annulus, but the *debris* and fine matter come up to it in close proximity, while the *Cyclotella* has a clear, well-defined space around it, nearly as wide as the diameter of the diatom. I put on the slide a little soluble blue, so that it dissolves and runs under the cover-glass, and the sight is a beautiful one, not to be forgotten nor confounded with the narrow and insignificant light which may, through refraction or reflection,

surround other diatoms and grains of sand under like condition. Only one class of objects that I have seen approaches to a similar appearance, and that is the spores and Gonidiæ of the Confervoideæ, which we know to be ciliated or surrounded by so thick a gelatinous mass as to prevent the near approach of light bodies.

Asterionella formosa is found in our water-supply I think at all seasons of the year, mostly, however, when other diatoms are plentiful. The representation of this beautiful diatom in our various elementary treatises, in the fractional form, is, in my opinion, erroneous. From repeated observations of many mounted specimens, I believe that it coheres in the stellate form, just as other *Fragillaria* cohere in filaments.

Of the one hundred and ninety-two microscopic forms figured and described by Mr. Vorce, of Cleveland,* we have found in Buffalo one hundred and seventy in our water-supply. A few of his forms I cannot quite make out by his drawings, some of them being very difficult to represent on paper. I congratulate him upon giving us so faithful a representation of so many familiar forms.

I will copy from my notes a few forms taken at intervals during many years. Diatoms: *Fragillaria pectinalis*, *Fragillaria capucina*, *Fragillaria crotonensis*, *Gomphonema capitatum*, *Gomphonema olevaceum*, *Gomphonema acuminatum*, *Tabellaria flocculosa*, *Cocconema fusidium*. October 24, 1874: Two fine large discoid diatoms, larger than *Stephanodiscus*, *Amphipleura sigmoida;* several forms of *Surirella*, *Cymbella ehrenbergii;* several forms of *Pluerosigma*, *Amphiprora ornata*, *Rhizosolenia Eriensis*, *Rhizosolenia gracilis*. This last form of *Rhizosolenia* I collected from the water-supply, in the latter part of June, 1882. I sent the whole gathering to Prof. H. L. Smith, who informed me of the presence of this new diatom, and that he had named it.† *Navicula serians*, and many others; *Melosira varians*, *Synedra ulna*, *Cocconema lanceolatum*, *Meridion constrictum*, *Diatoma vulgare*, *Cymatopluera solea*, *Cymatopluera elliptica*.

Of other interesting objects, I may mention *Acineta tuberosa*, with tentacles expanded; large *Stentor* without cilia on the outside, several smaller ones the same time; many *Actinophrys sol* in different

* Proc. A. S. M., Vol. III-51.
† See page 177.

stages of development; *Amœba* found occasionally; *Polyarthra platyptera*. This beautiful and curious rotifer was very common three or four years ago, but has not been seen, by me, at least, for two or three years.

Desmids: *Staurastrum gracile*, *Pediastrum granulatum*, *Ankistrodesmus falcatus*, *Scenedesmus quadricaudatus*, *Dinobryon sertularia*,—both dead and living form,—antheridia of *Polytrichum communis*, several forms of *Closteria*, some of which are not described in any work at my command; *Merismopedia nova*, *Spirillum*, *Ceratium longicorne*, the ever-present *Anguillula fluviatilis*, *Anuræa stipitata*, the long-horned rotifer, now *Anuræa longispina*, Kellicott. The exact time that I first saw this rotifer, I cannot now recollect. In looking over some old letters from Prof. H. L. Smith, one, dated February 7, 1874, refers to the rotifer in answer to some questions that I had previously asked. On June 10th of this year I found one of them in the water-supply, with flexible carapace, which could be bent and straightened at will. The one single red eye, as figured by Prof. Kellicott, was very conspicuous, and the internal structure was displayed with more clearness than I had ever seen before. I supposed the animal to have been a young one, which would account for these appearances, which are not to be seen in older specimens.

The forms of animal and vegetable life in the river during summer and autumn, are so numerous and varied in character that the microscopist who wishes to distinguish himself can desire no better field in which to work. Every exploration will afford him new material in such abundance that he will be unable to work it up while it is fresh. The acres and acres of still, or partially still water along the margins of the river, abound in every form of aquatic weed and *algæ*, which, with the stones aud rocks, and other objects on the banks, are so covered with life that one is almost bewildered with the innumerable forms, and realizes more than ever the force of the fiat that went forth of old: "Let the waters bring forth abundantly the moving creature that hath life."

In the early summer the rocks and all hard substances and immovable objects in the shallows are covered with diatoms, mostly of the smaller kinds. These appear in large, fawn-colored patches, extending over many square rods or acres. These patches consist

of *Fragillaria*, *Gomphonema*, *Synedra* and small *Navicula*, and the *Encyonema constrictum*. In June, of this year, large fields of these diatoms were conspicuous in the old mill-race, on the Canada side, near Buffalo, and also in the rapids at Niagara Falls; in either of which places it would have been possible to procure bushels of diatoms.

As a bare enumeration of the forms of animal life which one may find in Niagara River would be tedious and unprofitable, I shall mention only a few that appear to deserve more than a passing notice; one of these is an *Ophrydium*. This beautiful infusorium is found in August and September, in the form of a small, transparent mass of jelly, mostly circular in shape, adhering closely to the under side of stones and pieces of wood near the margin of the river. These little patches of jelly, from two to three lines in diameter, may easily be transferred to the collector's bottle with the point of a knife, and will remain good for examination for several days if carefully treated. When transferred to the stage of the microscope, they contract for a little while, and, as Dr. Evarts says,* assume a pyriform shape, but if allowed to remain quiet in a warm room, they will soon display great activity, extending themselves, everting their peristomes, and causing their cilia to move with great rapidity, and presenting altogether an appearance of great interest. The species we have found in Niagara River corresponds with the one described by him in his excellent article. In the last number of W. Saville Kent's Manual of the Infusoria, at page 738, vol. II, plate XLI, he figures and describes three species of *Ophrydium*, viz., *versatile*, *eichornii* and *sessile*. I have had no opportunity to study the living animal this season, therefore can come to no independent conclusion with regard to it. Mr. Kent, however, says that *Ophrydium adæ* of Dr. Evarts is a synonym of *Ophyrdium eichornii*, and that no new data are recorded by Dr. Evarts' article.

Trachelius ovum is another interesting infusorium, and was found in some weeds in the autumn of 1881. It is a large, ovoid form, with a long, pointed beak, curiously covered with cilia over its whole surface. I have found but one group of these curious infusoria, but it appears they are well known, and are described and fig-

Am. Mon. Mic. Jour., vol. I, 1.

ured by W. S. Kent at page 522, vol. II, plate XXVII, fig. 38. Their habitat is set down as bog-water by Kent. The precise location in the river where I obtained them I cannot now remember, but it was certainly from some of the weedy beds on the river-banks.

Some time in October of last year I placed a piece of sponge, *Carterella tubisperma*, with some *Chara* and *Myriophillum*, in a glass jar for preservation during the winter. As I went to the jar from time to time, I soon noticed that nearly all the contents were being covered with a green coating, and that the *Chara*, especially, was not healthy. At length I removed some of it for examination, and found the green covering to be an *Oscillaria*, which was clinging so closely to both *alga* and sponge that I had no hope of saving either through the winter. The *Chara* died after about two months, the sponge lived till May, and the *Myriophyllum* is not yet dead. The *Oscillaria* I am compelled to regard as *O. limosa, Agardh.* Prof. Farlow, of Cambridge, to whom I sent a small piece, considered it *O. leptotricha*, but its appearance under the microscope corresponds with the description of *O. limosa* in Wood's N. A. Algæ. It is about one-six-thousandth of an inch in diameter, attentuate at one end; cells a little longer than broad, and can only be seen with a high power of the microscope; filaments long, waving, curled, adhering closely to the *algæ*, and when grown in a jar is of a dark olive-green color, having a peculiar, musty, fetid smell which will remain on the fingers for some time after the *Oscillaria* has been in contact with them. The sponge, months ago entirely enclosed by the coating of the *Oscillaria*, is also infested with many beautiful worms; also multitudes of the *Tardigrada.* The latter are, or were, so numerous that the smallest fragment that could be picked off would contain three or four. The skins of the Tardigrades were also present, in many cases containing an egg or two, and in one case no less than fourteen were found in the cast-off coat of one Tardigrade. *Anguillula fluviatilis*, *Euplotes vannus* and others are enclosed, some living on the sponge and some on the *Oscillaria.*

Among the microscopic *algæ* found in the Niagara River, are several kinds of the *Characeæ.* I have found *Chara fœtida* in great abundance for several years at the foot of Amherst street, Black Rock. I find another species, *Chara coronata*, growing in a

shallow place, where the water has but little flow, about a third of a mile below the flour mills, on the pier. This species is admirably adapted to the use of the microscopist, from the fact that it is slender in form when grown artificially, very free from limy deposit, and entirely free from cortication. When first discovered, it was supposed to be a *Nitella*, but from correspondence with Prof. Farlow, of Cambridge, and an article by Dr. Allen in *The American Naturalist* for May of this year, I find that is *Chara coronata*, and is an exception to the cortication usually found on *Chara*. According to Prof. Farlow, the distinguishing feature between *Chara* and *Nitella* is that the former has but a single crown of cells, on the fruit, while *Nitella* has a double row of the coronula cells, on the fruit. Dr. Allen figures and describes eleven varieties of this species. He says the varieties are greatly dependent on the conditions of growth, and retain the peculiarities of the variety through many years.

Chara coronata is generally free from incrustation, but Mr. Allen says he received a specimen from the northern part of Canada so incrusted as to be quite grey when dry, and extremely brittle. Another specimen from near the same place has a most peculiar zonular incrustation, giving the plant, especially when viewed from above, a variegated appearance. This peculiarity is one of the distinguishing features of our specimens. The stems and bracts are almost entirely free from incrustation, while the outspreading branches have the zonular patches and variegated appearance.

The cell contents of the *Characeæ* consist of a fluid, or as it is sometimes called, a semi-fluid protoplasm, transparant, but carrying with it shapeless particles of chlorophyl and other matter needed to build up the plant. These particles vary in size from those which can scarcely be seen with the highest powers, to those which may be seen having the appearance of large gelatinous aggregations of the smaller ones, with the very lowest powers. Besides these shapeless masses there are sometimes, mostly in old specimens, numerous chlorophyl globules which appear to have been broken off from the inner wall of the cell. These are carried along by the rotating fluid, and must not be considered a portion of the cell-contents proper. They may, however, assist the observer to note more

certainly the course of the current and rate of motion. It will be observed that the current passes up one side of the stem, changing its direction only at the extremity of the cell, and flowing down the other side. The boundary line denoting the limits of ascending and descending currents as figured in some elementary works, I have never been able to see, and am disposed rather to regard such line as an optical illusion than a physical fact. To all who have paid close attention to cyclosis in the few plants that are most in favor with microscopists, the difference between the rotating fluids of the *Characeæ* and that of *Vallisneria spiralis* and *Anacharis Canadensis* must have become apparent. The fluid in these last named is hyaline, and almost entirely free from everything except comparatively large chlorophyl globules which continually, in their rotary motion, rub against the cell wall with great apparent persistency. As the cells in these plants are so much smaller than in the *Characeæ*, the observer can witness the entire revolution of the *ovoid* rather than *globular* chlorophyl grains press themselves up on one side, across the end and down the other side, and so on. Neither of the plants can be relied upon to show cyclosis with the same promptness and certainty as the *Characeæ*, but if a good lively specimen can be obtained and viewed under a high power, with strong light, the glare being subdued by a diapraghm, a most pleasing sight is presented, and one that can never be forgotten either by amateur or specialist. No one, however, may consider that he has seen cyclosis in its best form, unless he has seen it in the rootlet of *Nitella*, which is so hyaline and so minute, that the up and down currents can be seen without change of focus.